"SCREENING AND PRODUCTION OF SUSTAINABLE VALUE-ADDED MATERIAL FROM AGRICULTURAL RESIDUES"

Ph.D. Research Plan

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Of

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by

Mahima Jain

Under the Supervision of

Dr. Sonali Pandey

Professor, Department of Botany

School of Sciences

JECRC University, Jaipur

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INTRODUCTION

India is a developing country in which agriculture has now become the backbone of our country for its economic growth. Although, along with agriculture, horticulture, apiculture, sericulture and animal husbandry also plays an important role in our country economy. The geographical area of India account for about (2.4%) and water resources comprises of (4.2%) but hold up to (17.6%) of its population, which indicates that due to its large population related to its geographical area and water resources there is a significant exertion on India's natural resources (NPMCR ,2014). The gross fixed capital formation (GFCF) is recorded at (16.5%) of its gross value added (GVA) in year 2019-2020 for agricultural sector (Kimothi *et.al*,2020). As per the estimates by {directorate of economics and statistics, MOA, DAC, new Delhi, India} produced around 105.24 million tonnes(Mt) of wheat, 16.03 Mt of millets (jowar, bajra, ragi), 341.20 Mt of sugarcane, 22.26 Mt of maize, 7.79 Mt of fibre crop (jute, cotton, Mesta), 18.34 Mt of pulses and 30.94 Mt of oilseed crops (NPMCR ,2014). Among these crops rice, wheat and sugarcane is accountable for higher financial return. Cereals among all field crops are the foremost source of food for animal and feed for cattle. Cereals provide carbohydrate, dietary fibre and minerals to human and animals. Rice & wheat is the most essential cropping system in our country. According to the data presented by the FAO, around (33.33%) of the edible products produced for utilization are wasted. This equates to around 1.3 billion metric tons of food annually. This includes around (30%) cereals, (20%) dairy, and (35%) seafood and fish products (Taneja *et.al*,2023).

With the increasing population there will be a competition for air, land, water and other resources from non – agricultural sector which will exaggerate production of agricultural crops in near future eventually leading to production of more agricultural waste (Dwibedi *et.al,2021*). According to the report of united nation (UN) and food and agriculture organisation (FAO) (UN2019) the population is expected to rise from 7.7-8.6 billion in 2030 to 9.7 billion in 2050 so, the current production of food will not be enough. This high production need is not good for the environment and for the human health. Food demands will increase the food waste, pollution. About 931 million of food waste was generated yearly from households, industries and retail start-ups as per the reports by united nations environmental programme food waste index report UNEP (2021). According to the Organisation for Economic Co-operation and Development (OECD), agricultural waste refers to the waste produced by various agricultural

activities, such as the use of pesticides and fertilizers in water systems, the harvest of waste, and the disposal of manure and field residue. It also includes salt and silt that have been drained from fields. It is a significant quantity of food and agricultural production that has been mislaid (Sarvanabhupathy *et.al,2023*). Approximately, the agriculture sector provides about 24 million tons of food globally (Adejumo and Adebiyi,2020).

As the agriculture sector is helping to improve the economy of our country and also securing the food needs of our people, Due to the increasing population and resource competition there is an improper governance of the Agro – waste generated in the process, leaving less scope for reusage of the agricultural waste in majority of cases. This agricultural waste leads to Air, Water and Soil Pollution. Worldwide, annual waste from agriculture generated is approximately around 5.5 billion tonnes. All in all, 400 million tons of agriculture waste is generated every year and only a small fragment of waste is recycled or put to use in manure, animal feeds and other value-added commodities, there is a capability to produce biodegradable, sustainable products from this waste (Maraveas,2020). As per the roughly calculated value given by ministry of new and renewable energy, this waste can give rise to more than 18,000 w of power every year apart from creating green fertilizer for agriculture use. In the world, about 1.3 billion tonnes of waste is generated from the food consumed by human, out of which one – third is alone from the daily practices of household kitchen (Kimothi *et.al*,2020).

Agri-waste is managed inefficiently and mainly unattended as many of the farmers don't know about it or don't have enough sources to manage it properly, they don't know about the adverse effects of this waste on human and animal health. Year after year, a massive ton of solid agri-waste is generated, with (7.5%) of yearly increase rate (Adejumo and Adebiyi,2020). This gives rise to repellent odour, emission of harmful gases like Green House gases (GHG) around the junkyard. Farmers burn the farm crop residues sedentary in absence of any proper sustainable technology to recycle the waste that eventually leads to pollution and increase in carbon content. This waste generated leads to pollution increase in aquatic and air environment.

Rajasthan is an agriculture-based state where production of different crops varies and depends on the various physical factors like climate, soil type, temperature etc. The rising number of people living in poverty and climate disasters have negatively affected our communities. Due to the emergence of the COVID-19 pandemic, some communities are already on the verge of

collapse. This is why it is important that stakeholders adopt new measures to maintain a balanced environment.

One of the most effective ways to improve the resilience of our communities is by implementing policies and programs that support the transition to a more sustainable society. Sustainable development is important for a bright future and also it will protect the environment (Richards and Yabar,2023). The covid-19 pandemic has led to many challenges and threaten the food sector and enterprises. Besides keeping the public safe from the coronavirus, implementing strict sanitation rules can also reduce the compliance of businesses with maintainable practices. This is because they impact the share of food waste and the use of plastic packaging. Around 400 million tons of synthetic plastics are generated globally and only around (9%) is recycled back and there is no account of how much damage these plastics can cause to our environment (Maraveas,2020).

Around (30%) to (50%) of the fruits and vegetables grown in the country go to waste annually. Food waste treatment poses a significant ecological hazard due to the excessive consumption of electricity and the formation of various impurities (Taneja *et.al*,2023).

In our study we will try to focus on cereals, pulses and oilcakes. It will be another solution for the waste generated through these crops. Many solutions have already been found out but of course looking at the current scenario and the amount of waste generated there is a need to constantly find the cure or alternatives to the waste causing nature and human health problems. One hundred and forty billion tons waste annually in world is produced alone by agricultural sector and there is no useful commodity produced during the disruption process (Lade *et.al*,2023).

Among all crops, cereals contribute maximum waste(352Mt), pursued by fibres (66Mt), oilseeds (29Mt), pulses (13Mt), sugarcane (12Mt). Cereal crops (rice, wheat, millets, maize) give rise to 70% of waste (NPMCR,2014).

In 2013-14 under pulses Rajasthan had a total area of 4197.7 thousand hectares and 2490.0 thousand tonnes of production and 593kgs/hectare of productivity (Sharma and Bhushan,2019). In 2020 production of pulses was 4,497.100 tonnes hectares. (Directorate of Economics and Statistics,2020)

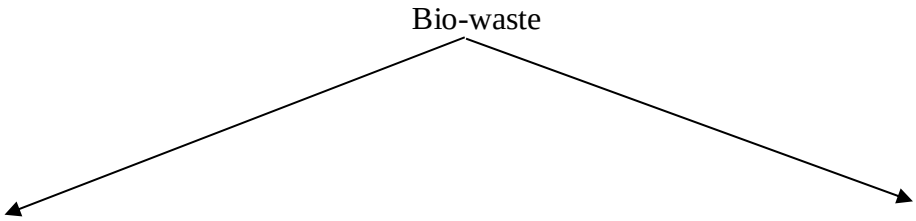
"The production of oilseed in Rajasthan takes place under 52.79 lakh hectare of area and production of 60.69 lakh tonnes." Rajasthan is the second largest oilseed producing state of country (Kumar *et.al*,2015).

Types of Agriculture Bio-waste: -

Cereals are the major residue forming crops about (70%) of residue is generated by cereals. The waste from agriculture residues is10-15 times more than the actual product formed (Sangmesh *et.al*,2023).

Farm residues are divided into different categories on the basis of activities carried out in the farm field and this categorization of field crop residues may differ pivot on particular context and region, here are some common types of residues found: -

Field crop residues are the remaining or surplus part of crops which is also called as the left over or discarded plant parts after crop harvesting. These residues are ordinally the surface ground parts of the plants like stalks, leaves, stems and all the supplementary parts that are not used for the final crop product. They can be divided into two types: -



(a) **Field Residues** – which are the crop parts left on field after the crop is harvested. For example – stubble, leaves, seed pods, stalks. These residues can increase the control of erosion and irrigation.	(b**) Process Residues** – These are the parts which are left after the harvested crop is being converted into a usable form. For example – husks, roots, molasses, Bagasses). This type of crop residue can be used as animal feeder, soil amendment, fertilizers and in manufacturing.

Agro – wastes are also acquired from sources such as wheat straw, palm oil fibres, tomato pomace, grape pomace, pineapple, orange, lemon peels, sugarcane bagasse, rice husks, oilcakes of groundnut, mustard, sunflower, sesame, coconut, soybean, palm oil fibres etc.

According to food and agriculture organisation (FAO) the food and vegetable discarded can cause up to (20-30%) waste during post - harvest handling (Marveas,2020). The food and vegetable oil processing industries generate vast amount of organic waste every year and is left untreated, not utilized in most of the cases. It is an estimation that (12.9%) of food waste is generated during cereal manufacturing and processing and (30%) of cereal weight is wasted (Farcas *et.al*,2022). The governance, management and implementation of these field crop residues depend on various factors like environmental contemplation, native agricultural practices and the technologies available in our country. In a developing country like India where there is still a problem of decomposing the waste as this waste causes many environmental problems, human and animal health issues as well. A representative chemical analysis report for comparative study on few Agri-biomass are illustrated in the table (Taneja *et.al*,2023).

Table 1. Components of Pre-Harvest Agricultural Residues. (Taneja *et.al*,2023).

Agricultural Residues	Chemical Composition (%*w/w*)					
	Cellulose	**Hemicellulose**	**Total Solids (%)**	**Moisture (%)**	**Lignin**	**Ash (%)**
Barley straw	33.8	21.9	ND	ND	13.8	11
Wheat straw	32.9	24.0	95.6	7	8.9	6.7
Cotton stalks	58.5	14.4	ND	ND	21.5	9.98
Sugarcane Bagasse	30.2	56.7	91.66	4.8	13.4	1.9
Sugar beet waste	26.3	18.5	87.5	12.4	2.5	4.8
Rice straw	39.2	23.5	98.62	6.58	36.1	12.4
Corn stalks	61.2	19.3	97.78	6.40	6.9	10.8
Sawdust	45.1	28.1	98.54	1.12	24.2	1.2
Oat straw	39.4	27.1	ND	ND	17.5	8
Soya stalks	34.5	24.8	ND	11.84	19.8	10.39

Agricultural Residues	Chemical Composition (%*w/w*)					
	Cellulose	**Hemicellulose**	**Total Solids (%)**	**Moisture (%)**	**Lignin**	**Ash (%)**
Sunflower stalks	42.1	29.7	ND	ND	13.4	11.7
Nut shells	25–30	25–30	ND	5.02–7.79	30–40	ND
Rice husk	21.5	33.1	89.41	10–15	14.6	20
Sugarcane straw	40.8	30.8	ND	35–50	25.5	5.3
Sorghum bagasse	40.4	35.5	ND	8.52	3.9	5

Table 2. Chemical Composition of Post-Harvest Agricultural Residues/ Industrial Waste (Taneja *et.al*,2023).

Type of Food Waste	Chemical Composition/Elemental Composition (%*w/w*)							
Waste	**Carbon**	**Cellulo-se**	**Nitrogen**	**Hydrogen**	**Hemicellulose**	**Lignin**	**Ash**	**Moisture**
Potato peel	1.3	2.2	9.1	ND	ND	20	7.7	9.89
Orange peel	3.87	9.21	ND	ND	10.5	0.84	3.5	11.86
Coffee skin	ND	23.77	ND	ND	16.68	28.58	5.36	ND
Pineapple peel	40.8	18.11	0.99	ND	47.72	1.37	ND	91
Wheat bran	49.81	24	0.7	6.11	ND	6	5.5	5.5–9.25
Rice bran	48.39	35	0.89	5.43	25	20	17	5.4
Corn cob	53.61	15	1.91	8.97	ND	6.2	ND	24-28
Corn stover	44	ND	0.8	6.3	17	ND	6.6	ND

What is agricultural burning?

Agricultural burning is setting the agricultural open field on fire purposely for preparing the land for next crop or to bring the life of pests and weeds to an end (Dwibedi *et.al*,2021). This practice is most common in north-western parts of India which results in nutrient loses, sincere air pollution and influencing health of human and animals (Saharawat and sidhu,2014). Most of the farmers don't know anything about management of the agricultural waste so, they follow this traditional practice of burning the waste generated as Burning is inexpensive and a rapid method to eliminate the trash of crops. The excess residue of crop production in India is roughly calculated to be 178 million tons and from this 87 million tons is set on fire (Kumar *et.al*,2023). Universally total burnt residue generated from rice is (24%), wheat gives (23%) of burnt residue, sugarcane gives (5%) and (48%) from maize. In India about (70%) waste is from cereals, rice contributing (34%) and wheat (22%). In the table 3 there is a list of total burnt residue generated from different countries (Dwibedi *et.al*,2021): -

Table 3. (Dwibedi *et.al*,2021): -

Country	**Agricultural waste generated (million tons/year)**
Myanmar	19
Indonesia	55
Bangladesh	72
India	500

Adverse effect of burning: -

The adverse effects of crop residue burning are –

1. **Loss of nutrients**–burning of 1 ton of rice straw generates an estimate of 5.5kg of nitrogen(N), 2.3 kg of phosphorus(P), 25 kg of potassium(K), 1.2 kg of sulphur(S) besides, organic carbon(C). in general, crop residues of discrete crops contain (50%) of

sulphur, (25%) of phosphorus, (80%) of nitrogen and if they assimilated in soil itself, then the soil gets enhanced with organic carbon and nitrogen. (Dwibedi *et.al*,2021)

2. **Effect on soil properties** – burning of residues produces heat which will increase the temperature of soil eventually killing helpful microorganisms.
3. **Outrush of greenhouse and other gases** – gases like CH_4 , CO , N_2O , NO and other hydrocarbons are produced due to residue burning.
4. Burning of crop residues elevates the content of black carbon and also decrease soil fertility which is remunerated by usage of fertilizers and eventually reducing agricultural productivity (Mehta and Badegaonkar,2023).

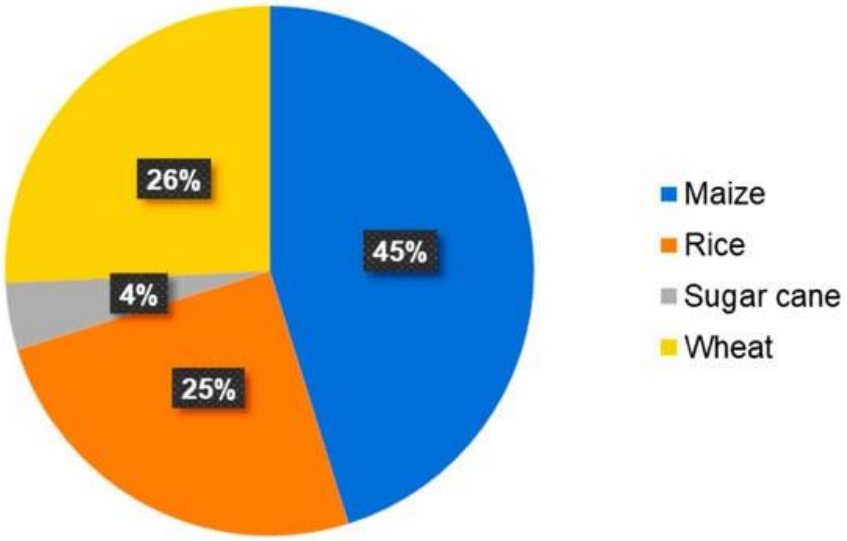


Figure 1. Emissions (CO_2 equivalent—Gg) from the burning of crop residues (source: Food and Agriculture Organization (FAO) (Sarkar *et.al*,2020)

Beneficial uses of Agro-Waste:-

If the agro-waste generated is treated properly and managed well then it can be used in various industrial and beneficial purposes. Crop residues have been used for soil mulching, biogas production, bio-fuel for industrial and domestic purpose, feed for livestock. Some of the uses are given in the chart below –

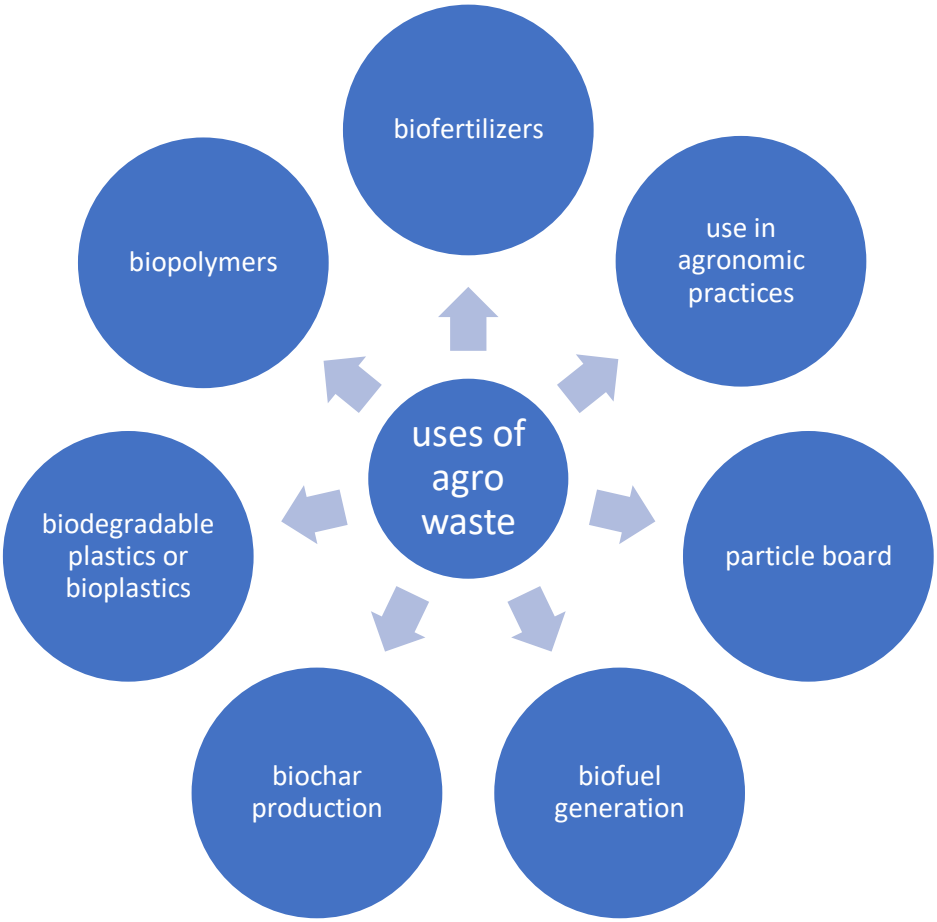


Figure 2. Some Beneficial Uses of Agro-Wastes

Waste from agriculture also construct a massive amount of biomass known as Natural fibres which can be utilized for construction materials, for decorative items and as a versatile raw product.

The cheap source for cellulosic fibres are lignocellulosic by-products of agricultural activities like stalks, straws and cobs etc. These can be an initiating stuff to make extremely valuable cellulose nanofibrils, sustainable fibres which have low density and they are biodegradable.

For production of textiles and other purposes natural fibres are used as they have the ability to decompose themselves, and have a positive effect on environment, for ex- cotton, jute, wool, flax are some commonly used fibres. Making of biopolymer-based composites from agri-biowaste is a hopeful proceed towards development of composite materials (Gowda *et.al,*2023)

According to the above compiled information or data collected, it is observed that the cereals, many oil yielding crops and legumes like gram, moong, cereals like wheat, rice, bajra, oilseeds like groundnut, flaxseed generate a lot of waste and create immense amount of environmental

pollution and health problems. A number of useful products are made from these generated wastes and still there is a potential to produce some novel useful products from them which might offer a remedial solution for the agri waste problem to produce something useful eco-friendly commodity, reusable, economically helpful, sustainable, biodegradable products and which can benefit the society in some or the other way.

Review of Literature

Mehta and Badegaonkar (2023) studied about the condition of crop residue management in different countries and the progress in enhancing the waste usage for producing sustainable resources was discussed by Lade *et.al*, (2023).

The use of various application of crop residues in industries, their problems and the issues in the sustainable management of crops was discussed by Kumar *et.al*, (2023)

Sangmesh *et.al*, (2023) reported the application of agricultural wastes as a commercialy viable technological solution for building construction materials that will ease the use of natural resources and will be safe for the envionment.

Ramakrishnan *et.al*, (2023) concluded that the bricks can be made more sustainable , economically feasibleand biodegradable by using the specific agriculture waste materials to manufactre bricks.

Gowda *et.al*, (2023) addressed the capability for biopolymer-based composite made from agriculture biomass which can replace conventional materials in a sustainable and accountable manner.

The Valorisation of potential sources of biomass into different bio-commodities ranging from fuel to biopolymer application. They also deal the valorisation processes and their advancements in terms of nanotechnology accompanying the future aspects and challenges Saravanabhupathy *et.al*, (2023)

Richards and Yabar (2023) reported the appropriate waste management technique of using bio gasification system for recovery of resources and the food waste derived metabolic compounds and their sustainability and feasibility which is a profitable alternative to waste management. they also outlook the market probability and food waste recycling was elucidated by Taneja *et.al*, (2023)

Farcas *et.al*, (2022) They provided an overview to release the bioactive compound from bio-waste by some extraction methods and some advanced treatments. Methods like acid and alkaline hydrolysis, extraction of solvent, Soxhlet extraction are some of conventional methods. Treatments like enzymatic-assisted extraction, ultrasound-assisted extraction, microwave-assisted extraction are some advanced technologies.

Dwibedi *et.al*, (2021) discussed about the attempts made to coherent various sustainable crop residue management ideas like residue incorporation, composting, production of biochar, biofuel production, production of biogas, particle composite board making, paper making and packaging etc.

Aneke *et.al*, (2021) demonstrated a successful approach towards the manufacturing of masonry bricks by using a mixture of polyethylene terephthalate (PET) waste and sand and Different worthy residue management technologies without harming the environment sustainability and the productivity of agriculture were put together Sarkar *et.al*, (2020).

Directorate of economics and statistics, department of agriculture and farmers welfare (2020), reported the agricultural production of pulses in Rajasthan from 1981 to 2020.

Adejumo and Adebiyi (2020) studied some of the challenges associated with agriculture waste and their management. They intend to study about the main solid waste from agriculture, their potential risks and their proper management.

Mafongoya and Sileshi (2020) reported that waste from agriculture also construct a wide amount of biomass called as natural fibres which can be used for building and decorative products. Stalks, stems, straws and cobs are some lignocellulosic by-products which a despicable source for cellulose fibres. These by-products are recommended as a source to produce valuable nanofibrils, fibres which are renewable, biodegradable and low density.

The source of agro-wastes are very diverse like tomato pomace, rice husks, wheat straw, palm oil fibres, sugarcane bagasse, orange and lemon peels, etc. universally, 400 m tons synthetic plastics are produced and only (9%) are recycled. According to FAO (20 – 30%) of vegetable and fruits wastes are discarded. So, new effective and low-cost techniques are necessary for the production of bio-polymers which are better than synthetic ones as these will pose a minimum threat to the environment were reported by Maraveas (2020)

Kimothi *et.al*, (2020) compiled a book on all technologies of creating wealth from agriculture waste which involves 140 technologies which explored the different areas of creating wealth

by utilizing all the waste generated from agriculture weather during crop harvesting, crop processing, product synthesis etc. some of these technologies are already commercialised and some are still processing, these technologies are a start for new business opportunities and will help in creating a strong and Atamnirbhar Bharat.

Sharma and Bhushan (2019) reported the return pulses to farmers, to society and to environment were roughly calculated across zones at economic price.

Mostafa *et.al* (2018) reported that management of agro-waste is very critical in order to maintain quality of environment. They reported an efficient method to produce cellulose acetate biofibre from cotton linters and flax fibres. They confirmed the bioplastic structure by X-Ray diffraction, FT-IR and gel permeation chromatography and this new bioplastic is applicable in both food and medicine industry.

Koop and Leeuwan (2017) concluded that today the prime concern of world should be to solve the water crisis, manage the solid waste generated and adapting the climate change.

Kumar *et.al* (2015) stated in a book called production technologies for Rajasthan that our daily diet constitutes edible oils as an important part. Rajasthan is the second largest producer of oilseed and it has further scope to increase its production.

Saharawat and Sindhu (2014) found that in north western parts of India rice straw burning is very common and it causes serious health and environmental problems. to manage the rice residue, they said mulch is good option during wheat crop with no tillage. Mulch increases yield, efficiency of water use, profit and it decreases the pressure on weed and same with the wheat residue, it can be used in paddy fields with no effect on rice yield. They also gave some other option to manage the R-W residue for producing biochar for increasing nutrient use, and to upgrade soil health.

In National policy for management of crop residue (2014), NPMCR, there are discussed the adverse effects of burning of crop residue and the various management policies.

Justification for Selection of Topic

Keeping in mind the amount of waste generated by the crops there is a need to find the solution to tackle that waste. There is already been a lot of research done to handle that waste purposefully but also, we can't ignore the fact that the amount of waste is more than the solutions found out. Agriculture waste produced which is not utilized and lies down in soil and decomposes in a long time. India is a developing country where there is still a problem of decomposing the waste, and mainly our study will be based on Rajasthan(JAIPUR) which is an agricultural based state but still have a problem of waste management or a place to dump the waste to avoid the trouble caused by agricultural waste. In our study we will try to make products which can be used in daily household practices, house manufacturing items specially to help the poor. We will use the waste generated by these crops like cereals, fibres, oilseeds, pulses etc in a useful manner that is not used earlier in-house manufacturing items to help the society and especially people who comes under Below Poverty Line (BPL) for their shelter and other utilitarian products. So, this study will definitely help the society economically and find out the best available waste material for production of biodegradable and sustainable product which will dispose itself in place and will not cause any environmental problem or human and animal health problems. To make something new from the waste it is very important to keep in mind that it should not cause any environmental pollution and help to control it. This is what we will try to achieve in our study.

Research objectives

1. To Survey the Cereals, Legumes, Oilseed crops generated waste in and around Jaipur Tehsil.
2. To Screen and Develop Agri-Waste materials for the production of Ecologically Sustainable Product.
3. To Perform / Conduct Physico-Chemical test for the Durability of Produced Product.
4. To Recommend Best Developed Product with Desired Sustainable Qualities.

SCOPE OF THE STUDY

The population of world has increased from 3.7 billion in 1970 to 7.9 billion in 2021. its prognosticated that it will reach 9 billion by 2050 to 11 billion by 2100 respectively (Koop and Leeuwan,2017). Thus, there is a formidable challenge of fulfilling the food need of people in the upcoming years. In order to satisfy the food needs of people there has to be more crop production which will ultimately leads to more production of agricultural waste. So, there should be some solutions present to treat or to handle the agricultural waste properly because that waste can be used to create something useful as we have collected the data that the waste can be used to make biofuel, biogas, bio-bricks and many other useful products. This research will help to find some other promising roles of Agri-Waste which will help the society economically, environmentally and eventually help in decreasing the waste from the country and will solve the health and environmental problems caused by these wastes.

This study will help us to develop some agri-product to help the poor section of the society by basically blending the waste products of different crops in combination and that will be economically useful and low cost. The focus of this research will be the effective use of the waste materials to convert them to construction materials or other useful commodities with very low carbon dioxide embodiment (Aneke *et.al*,2021).

Significance of study

- Nearly, every agricultural activity generates a vast amount of waste which unfortunately results in enormous economic loss, causes many human and animal health problems and it also cause a great damage to environment because there a very less information available on how to manage these crop waste properly and get rid of it. We will try to contribute a little in managing this waste by combining the waste of different crops in different compositions together and make a useful commodity for the poor section of society.
- Agro- wastes has shown the capability of a sustainable alternative to be used in construction works (Sangmesh *et.al*,2023).

Research methodology

1. The researcher will conduct a survey regarding crops grown in Rajasthan (Jaipur). The information of how much waste is generated by crops like pulses, cereals, oilseeds from the local farmers will be collected. Annual calendar of crops grown in summer, winter and rainy seasons. Cereals vs Legumes vs Oilseed crops – Percent waste generated and used parts in different fields.

2. Performing physico-chemical tests for the durability and life span check of the produced materials with the help of literature review, the data available in journals and other sources.
3. The researcher will do different types of test on the sustainable product made to check its authenticity and durability, tests like biodegradation tests by composting method, chemical tests in which effect of acid like sulphuric acid , effect of base like sodium hydroxide, effect of solid salts on the commodity produced, characterization test like x-ray diffraction test by using X-Ray diffractometer, gel permeation chromatograph will be done on the commodity produced(Mostafa *et.al*,2018).

(a) Physical tests-

1. **X-ray diffraction**: - It's used to gather information about the crystallinity and tensile strength of the product produced by using x-ray diffractor. X-ray diffraction pattern of product is recorded (Mostafa, *et.al*,2018) or can use tensile strength testing machine (Aneke et.al,2021).
2. **Initial rate of absorption**: - For durability performance of bricks in a damp/moist environment the bricks will be submerged in water to check the absorption of water after 1 minute of submersion. (Aneke *et.al*,2021).

   Water absorption in percentage: - $\frac{W2 - W1}{W2} \times 100$ (Ramakrishnan *et.al*,2023).

3. **Undefined Comprehensive strength test**: - by using a compression machine the crushing test will be done (Aneke *et.al*,2021).
4. **Dilution test:** - the sample of bricks made will be drowned in water for 24 to 48 hours to check the time it takes to get diluted in water.

5. **By composting**: - sample will be vaccum dried for24hrs at 45 degrees Celsius and then will be buried in municipal solid waste to examine the possibility of biodegradation. This waste consists of composting seeds, wood waste, food waste, cow manure, etc. also, by keeping the sample in oven at 55 degrees Celsius to check the maximum growth of thermophilic microbes.

(b) Chemical tests: -

1. **Treating agro-wastes with chemicals** like acids and alkali to extract lignin and cellulose(Maraveas,2020).
2. **Effect of acids**: - samples will be weighed and put into sulphuric acid n different concentrations to determine the weight loss of the product.
3. **Effect of alkali**: - samples will be weighed and put into a alkali solution like sodium hydroxide in different concentration to check its effect on the weight loss of product.
4. **Effect on salts**: - samples will be mixed with solid salt and to determine the resistance of salt on it. Salts like ferrous sulphate, sodium chloride, tri-sodium, lead acetate (Mostafa, *et.al*,2018).

Expected outcomes

The product made will be Biodegradable, Sustainable, Eco-friendly and Decomposable which is produced from Agri-Waste generated as by-product from different crops.

Work plan/Time lines

1-24 months	**Review of literature throughout the study**
1-3 months	**Collection of the waste from different crops in concern**
3-6 months	**Combining the crop waste in different proportions to check the best fit**
6-12 months	**Experiment setup and conduction of all the durability tests on the resultant product**
12-20 months	**Screening of resulted product to find out its worth**
20-24 months	**Thesis preparation**

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